DOCUMENT RESUME

ED 312 220 SP 031 497

AUTHOR Weidler, Sarah D.
TITLE Exploring Preservice Teachers' Knowledge Structures about Reading.
PUB DATE Feb 89
NOTE 37p.; Paper presented at the Annual Meeting of the Eastern Educational Research Association (Savannah, GA, February, 1989).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Cognitive Structures; *Concept Formation; Elementary Education; Higher Education; Learning Strategies; Learning Theories; Preservice Teacher Education; Reading Comprehension; *Reading Instruction; *Teacher Effectiveness; *Teaching Methods

ABSTRACT

Research suggests that preservice teachers who have organized knowledge structures are able to respond to instructional situations more effectively than those who do not. It appears that the way a teacher organizes knowledge influences how easily the information is accessed and applied in instructional situations. This study investigated the interrelationship between preservice teachers' knowledge structures about reading and their actual instructional actions. Three questions were posed: (1) Do knowledge structures about reading evolve or grow more coherent as new knowledge is acquired during a reading methods course? (2) Is there a relationship between the coherence of knowledge structures and effective instructional action? and (3) Do preservice teachers perceive a relationship between their knowledge structures and actual instructional practice? Ten preservice teachers were required to develop an "ordered tree" at the beginning, middle, and end of the semester. This exercise allows persons to display concepts included in their knowledge structures and how they are tied together into a network of relationships. Data from the study indicated that preservice teachers' knowledge structures grow more coherent as new knowledge is acquired and that knowledge structures appear to be associated with instructional practice. The subjects did not appear to perceive a relationship between their knowledge structures as reflected in an ordered tree and their actual teaching. (JD)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED312220

Exploring Preservice Teachers' knowledge structures about Reading

Sarah D. Weidler
Elementary Education and Reading
State University College at Buffalo
Bacon 321-C
Buffalo, New York 14222
(716) 878-4839

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

S. D. Weidler

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Paper presented at the annual meeting of the Eastern Educational Research Association
Savannah, Georgia
February, 1989

SP031497

The author gratefully acknowledges the data collection and analysis efforts of Alexandra Barrett in the preparation of this paper.

BEST COPY AVAILABLE

Exploring Preservice Teachers' Knowledge Structures about Reading

Teacher educators have shown an interest in investigating the relationship between the complexity and organization of teachers' knowledge about instruction and what actually happens when instructional decisions are made. Knowledge about instruction refers to a teacher's schemata or cognitive structure which is organized into meaningful units. Research suggests that teachers who have more organized knowledge structures are able to respond to problem situations more effectively than teachers who have less organized structures (Duffy & Roehler, 1988).

Paris, Lipson and Wixson (1983) contend that teacher thought is initially based on declarative knowledge. That is, the teacher needs to know "what" to teach before proceeding with instruction. Studies of teacher explanation suggest that effective teachers provide explicit instructional information at the beginning of a lesson about what is to be learned, when it will be used, and how to apply it. Additionally, effective teachers are able to respond spontaneously with unplanned but appropriate explicit explanations throughout the lesson. For instance, consider a teacher who is using a LEA strategy to elicit a story about a trip to the zoo from a group of first-graders. The teacher must have a sense of the appropriateness of LEA for first-grade, and must also be knowledgeable about the instructional procedures of the strategy. It is equally

important that the teacher be able to respond to an unanticipated situation, such as when a student suggests that, "My mother's name is Mary," would be appropriate to include in the group story about the zoo. The ability to respond spontaneously in teaching situations with alternative strategies is labeled "responsive elaboration" (Roehler, Duffy, Conley, Herrmann, Johnson, & Michelson, 1987).

The more teachers engage in responsive elaboration, the more effective they are when teaching and the greater their degree of metacognitive control over their knowledge about reading instruction (Duffy & Roehler, 1987). When teachers are in metacognitive control of their knowledge concerning an instructional outcome and how to approach teaching it, they are better able to adapt and adjust their instruction so that students have a clearer understanding of the intended message. In other words, it appears that the way a teacher organizes his or her knowledge influences how easily the information is accessed and applied in instructional situations (Herrmann, 1987).

The majority of studies previously described address the actions of established classroom teachers rather then preservice teachers who do not yet have teaching experience. Some similar research has been conducted on the organization of preservice teachers' knowledge about the teaching of reading and their instructional performance. These studies indicated that preservice teachers with more organized

knowledge structures tend to exhibit more expert-like behaviors than preservice teachers with less coherent knowledge structures (Herrmann, 1987; Roehler, Duffy, Conley, Herrmann, Johnson, & Michelson, 1987). While these studies provide insight into the relationship of preservice teachers' knowledge and their instructional implications, the knowledge base is limited. This study explores further the question of the relationship between the declarative knowledge and instructional practice of preservice teachers.

Research Questions

The purpose of this study is to investigate, in an exploratory manner, the interrelationship between preservice teachers' knowledge structures about reading and their actual instructional actions. Three research questions are posed:

1. Do preservice teachers' knowledge structures about reading evolve or grow more coherent as new knowledge is acquired during a reading methods course?

2. Is there a relationship between the coherence of knowledge structures and effective instructional action? In other words, do preservice teachers who have more coherent knowledge structures teach more effectively than preservice teachers with less coherent knowledge structures?

3. Do preservice teachers perceive a relationship between their knowledge structures and actual instructional practice?

Method

Subjects

Subjects included ten preservice teachers selected at random from among twenty-seven students enrolled in an introductory reading methods course at a large urban college in Western New York State. All subjects were in their junior year in college and had completed all prerequisite courses in order to enroll in a reading methods course.

Knowledge Structure Data Collection

An "ordered tree" technique (Naveh-Benjamin, McKeachie, Lin, & Tucker, 1986) was used to measure the preservice teachers' evolving knowledge structure about reading. This technique allows persons to display concepts included in their knowledge structures and how these concepts are tied together into a network of relationships. Prior to the beginning of the study, the subjects participated in an orientation to the ordered tree technique which included a description of the characteristics of an ordered tree and practice in constructing an ordered tree.

Three ordered trees were prepared by the subjects over the semester. For each tree preparation, the subjects were

given a list of seventy terms related to reading. All the terms were taken directly from the text used in the reading methods course or were included in the lecture portion of the course. The subjects were asked to group or categorize the words in ways that made sense to them. They were encouraged to arrange the terms into some sort of network which would show some relationship between or among groups. They were allowed to use the words more than once and could also add words or phrases that they thought would clarify the tree.

Immediately following the construction of each ordered tree, each subject was interviewed and asked to describe the relationships depicted among concepts and groups of concepts and various aspects of the reading methods course that influenced any thinking. Interviews were conducted by the course instructor and a graduate assistant.

The ordered trees were collected at the beginning of the semester, after eight weeks (mid-semester), and at the end of the semester. Totally, thirty ordered trees were collected from the subjects.

Analysis of Knowledge Structure Data

Ordered trees were analyzed using two criterial categories, a numerical measure and a coherence measure (Roehler, 1986). The numerical measure requires counting each tree's nodes (the total number of concepts included in the tree), chunks (the number of clusters of subordinate

concepts tied to each superordinate concept), the average number of concepts per chunk, and a combination of the tree's depth (horizontal levels of chunks) and width (number of chunks at the widest point). Previous studies of expert and novice learner's ordered trees suggest that experts' trees tended to be structurally similar, while novice learner's tree tended to vary to a great extent. Experts' trees contained about 100 concepts, about 30 chunks, an average of 2.5 concepts per chunk, and a total combination of depth and width of about 25 (Duffy & Roehler, 1986). The numerical scores are converted to ratings based on a ten-point scale derived from analysis of experts' ordered trees (Figure 1).

Insert Figure 1 about here

The second criterial measure, coherence, is a measure of logical relationships between concepts within chunks, and chunks which are vertically extended. In previous studies, novice learners' ordered trees tended to be less coherent than experts' trees. Experts tied concepts together in a more logical and consistent manner (Duffy & Roehler, 1986). When analyzing ordered trees for coherence, only relationhips between concepts within chunks, or across vertically extended chunks are evaluated. The level of coherence is determined by how closely the relationships

between chunks and vertical chunks reflects the content of the course and textbook. Credit is given if the relationships are logical; no credit is given is one or more of the relationships does not reflect the logic of the course.

All scoring was completed by the instructor and a trained graduate assistant. First, numbers were assigned to the subjects in order to conceal their identity; the assignments were then randomly divided between the two raters, with each rater evaluating the ordered trees of five subjects. Each rater analyzed the trees following the previously established conventions for both the numerical and coherence categories. The raters compared their scores for each tree and discussed any discrepant scores until 100% agreement was achieved.

Following each tree evaluation, the raters interviewed subjects to discuss the ordered tree networking. The subjects were encouraged to clarify any relationships between terms in the ordered tree that the raters perceived as unclear. In order to gain more information about how the subjects were organizing their knowledge and what might be influencing their organization, the raters asked the subjects the following questions during each ordered tree interview: (1) Explain the organization of your tree, (2) what has influenced the organization of your knowledge, (3) what kinds of things are you doing in class, (4) are you working with children in any other course, (5) compare this

ordered tree with previous ones - are there any changes (if so, explain), (6) what has influenced any changes, (7) have you organized the concepts in your trees in the same way or different ways, (8) which tree makes more sense (why).

In order to sample a preservice teacher's instructional behavior, each subject was videotaped teaching a reading-related lesson. Subjects had previously been assigned to elementary classrooms for the field experience portion of the methods course. The subjects were asked to prepare either an LEA lesson or a DRTA lesson depending on the appropriateness of the strategy for their particular grade level. Those students assigned to Kindergarten or first grade typically chose to prepare an LEA, while those assigned to third or fifth grade chose to prepare a DRTA lesson. All videotaping was conducted in a studio separate from the regular classroom, but contained within the school building. The raters were not present during the videotaping sessions. Each lesson ran from thirty to forty-five minutes in length. At the conclusion of the session, each subject met with the rater, viewed the videotape, and discussed perceptions concerning the lesson. Parallels between the organization of each subject's ordered trees and the content and progression of the lesson were also discussed.

Each videotaped lesson was evaluated against five criteria for either the LEA or DRTA procedure. Evaluation of a Language Experience Activity required that the subject

address the following criteria: (1) Provide a stimulus, (2) involve the children in oral discussion, (3) dictation, (4) reading the story, and (5) provide a follow-up. Raters determined whether each step of the lesson was handled in a satisfactory, unsatisfactory, or more than satisfactory manner. The decisions about the quality of instruction were not based on procedure alone. As stated previously, effective instruction involves more than being able to implement a memorized set of procedures regardless of the circumstances. Effective teachers typically provide students with a sense of direction before beginning a lesson and relate what is being learned to a learning outcome. They are able to make responsive elaborations when instructional situations occur that require alternate strategies.

For example, when determining the quality of instruction during the stimulus phase of an LEA, it was noted whether or not the subject provided a stimulus suitably motivating to the students or tied the stimulus into any kind of learning outcome or purpose for learning. In one case, subject 5 was working with a group of four kindergarten children and for a stimulus read them a book about mommy's jobs around the house. The book was seriously dated since it stereotyped the roles of men and women and, as such, was an inappropriate choice in the first place. Additionally, the subject made no attempt to tie the book's content into anything the children were learning about in

the classroom. At one point one of the children commented that the story was boring; the subject responded by claiming that the story would be over soon and that they would do something else. The subject received an unsatisfactory rating for the criteria of providing a stimulus.

Evaluation of a Directed Reading Thinking Activity required that the lesson meet the following criteria: (1) concept development prior to lesson, (2) vocabulary introduction, (3) purpose setting or making predictions by students, (4) silent reading, (5) purposeful oral reading or proving of predictions. As with the LEA, the raters determined if the lesson met each of the criteria in an unsatisfactory, satisfactory, or more than satisfactory manner. The ability of the subject to respond spontaneously to instructional problems, to encourage strategy use, and to provide purposes for learning were considered in the evaluation of the lesson. For example, when determining the merit of vocabulary introduction, if the subject chose to present selected vocabulary in sentences (irregular words which were not presented in context-rich sentences in the story), and also tied the new vocabulary to the story in some way, the subject received a more than satisfactory rating. For both the LEA and DRTA, 15 points represented the highest possible rating, while 5 represented the lowest possible rating.

Do preservice teacher's knowledge structures about reading evolve or grow more coherent as new knowledge is acquired during a reading methods course?

Patterns were studied in both the overall numerical ratings as well as the overall coherence ratings to identify any changes in the preservice teachers' organization of knowledge (Tables 1 and 2). For each preservice teacher, three ordered trees were evaluated and rated. One from the beginning of the course, one from the middle of the course, and one from the end of the course. The overall numerical and coherence ratings were noted at each point in time. Table 1 shows that the overall numerical rating score for each student's final ordered tree indicates an uneven pattern in organization of reading terms for all subjects. Six of the ten subjects had a higher numerical rating at the end of the course indicating that they had developed more extensive ordered trees.

Insert Table 1 about here

Table 2 displays the overall coherence score for each subject for all three ordered trees. All but one subject had a higher coherence rating at the end of the course indicating that the concepts included in the second and third ordered trees made more sense when organized in chunks and were more logically organized when one concept was

extended to another. It appears that preservice teachers' ordered trees do evolve over time in the sense that concepts are more coherently linked but may not necessarily show more organization or extensiveness.

Insert Table 2 about here

All subjects were interviewed after constructing each ordered tree and were asked which tree made the most sense. All subjects concurred that the third ordered tree was the most organized and made the most sense. They felt this was due to having a better understanding of the reading terms and how the terms fit together. Subject 3 commented that she felt her first ordered tree was "funny" and "mush" because she didn't know what the terms meant in relation to reading. She basically responded to the terms by how she felt they should go together. By the time she completed the third tree, she felt she knew about the meaning of the terms so that she could structure the tree in a more organized fashion. She felt her third tree had more purpose. Other subjects responded similarly to the same question. It appeared that all the subjects generally felt they knew more about the content of the reading terms on the list and were better able to organize the concepts by the time they had to complete their third tree. Interestingly, even those subjects who had less extensive trees at the end of the

course felt that their last tree made the most sense. This may be a reflection of the subjects responding to the coherence of the terms rather than how many terms they included from the list. Several subjects commented that they intentionally used fewer terms on the last tree because they had a better idea of what they felt should be included. This could possibly account for the lower numerical rating for several subjects since the number of concepts is an integral part of the numerical score. Figures 2 through 5 provide examples of the first and third ordered trees of two subjects. Subject 4's ordered trees exemplify more cohesive and extensive knowledge structures, while subject 6's ordered trees exemplify less cohesive and extensive knowledge structures.

Insert Figures 2, 3, 4, and 5 about here

Is there a relationship between the coherence of knowledge structures and effective instructional action?

Table 3 summarizes the numerical ratings of the videotaped lessons. The highest possible rating a subject could receive was a 15 and the lowest possible rating a 5. When comparing lesson ratings with ordered tree coherence data, it is apparant that most subjects with higher

coherence ratings (closer to 10) also displayed higher lesson ratings. Subjects 3, 4, and 9 who received coherence ratings of 7.7, 8.1, and 8.0 were also judged to be the most effective in terms of instructional performance, with each subject receiving 13 out of 15 points. Similarly, those subjects with the lower coherence scores tended to be rated as ineffective in terms of instructional performance. Subjects 5, 6, 7, 8, and 9 received coherence scores of 6.0, 5.7, 5.4, 6.2, and 5.75 and were rated as either a 5, 6 or 7 in terms of instructional performance. Subjects 1 and 2, who were close in coherence rating were rated very differently for their instructional performance. Subject 1 received a coherence score of 6.5, and an instructional rating of 6 while subject 2 received a coherence score of 6.7, but an instructional performance score of 10.

Insert Table 3 about here

Numerical scores from the ordered tree data also appear to be correlated with the instructional performance scores of the subjects, but to a lesser degree. Those subjects with numerical scores on the third ordered tree of 6.6 or higher all received instructional performance scores of 10 or higher. Two exceptions to this pattern were subjects 4 and 9 who received numerical scores of 5.8 and 3.3 on their third ordered trees but received ratings of 13 on their

videotaped lessons. Subjects 1, 5, 6, 7, 8, and 10 received numerical ratings of 4.1 or less on their third ordered trees and were rated as either 5, 6, or 7 on instructional performance.

Those subjects who were rated more highly on the instructional performance measure tended to exhibit behaviors indicative of effective instruction: (1) they let students know what they intended to accomplish during the lesson, (2) when viewing the videotape, they were more aware of problems and responded to problem situations with alternative suggestions, such as noticing when they should have asked students to predict events during the DRTA, (3) they involved the children in the lesson, such as encouraging children to help spell letters or words during the dictation portion of the LEA that had been introduced in the regular classroom, (4) they encouraged the children to see the relationship between what was happening in the lesson and what the childern were studying in the regular classroom, and (5) they were able to manage their group and keep the children on task.

In contrast, the preservice teachers who were rated as less effective: (1) tended not to set purposes for learning or reading, (2) were often not aware that the children were not involved in the lesson, even after viewing the videotape; for example, the subjects often answered their own questions and were not aware that they had done so, (3) rotely followed the procedures of a strategy (LEA or DRTA)

but were not able to elaborate responsively, such as not realizing the inappropriateness of asking a group of beginning readers to help correctly spell the irregular word "beard" during an LEA lesson, (4) never helped the children see that what they were doing had any relationship to what was happening in the classroom, (5) did not encourage the children to apply strategies or think critically, such as during the prediction stage of the DRTA, the students were asked to read the page and look up when they were finished and at times were encouraged to read orally in lieu of silent reading, and (6) often had management problems that took them totally off the task of teaching.

These data suggest that there may be a relationship between how preservice teachers organize and make sense of their knowledge about teaching reading and how effective they are as teachers.

Do preservice teachers perceive a relationship between their knowledge structures and actual instructional practice?

All subjects were asked if they were aware of any relationship between their thought processes involved in constructing an ordered tree and and their thought processes during actual teaching. The majority of preservice teachers did not perceive any tangible relationship between constructing ordered trees and their actual teaching. One

subject commented that as she prepared her third tree she reflected back on her teaching experience to help her organize the terms. Another subject commented that the teaching was a more spontaneous activity. Several subjects said that they really hadn't thought about any relationship between the two activities.

Summary and Tentative Conclusions

In summary, these data provide support for the hypotheses that preservice teachers' knowledge structures grow more coherent as new knowledge is acquired during a reading methods course and that knowledge structures appear to be associated with instructional practice. More coherent knowledge structures appear to reflect more effective instructional practice while less coherent knowledge structures appear to reflect less effective instructional practice. Preservice teachers do not appear to perceive a relationship between their knowledge structures as reflected in an ordered tree and their actual teaching. These data further support the conclusions of a previous study on preservice teachers' evolving knowledge structures (Roehler, et al, 1987) which reported similar findings on the first two research questions.

Analysis of the teaching behaviors of those subjects who engaged in effective instruction versus those subjects who did not provided some interesting patterns. Tentative conclusions only can be drawn since many variables can

affect performance. For example, videotaping a lesson can be disconcerting for both the teacher and children. In order to make the taping less of a contrived situation, the preservice teachers were encouraged to practice their strategy (LEA or DRTA) with the same group of children a number of times before setting up the videotape session. It was speculated that taping in a separate room would be less distracting than if the videotaping were conducted in the regular classroom. Ironically, in several cases, the videotaping arrangement appeared to be more distracting and the children were less manageable than if they had stayed in the regular classroom. Since the regular teacher was not present for the lesson, it is possible that the children took advantage of their situation. This seemed particularly true for subject 1's lesson. Her lack of management skills directly affected her instructional performance score. One child in her group totally disrupted the lesson, and rather than removing him from the group, she continued to attempt to teach. Had the lesson been conducted in the regular classroom, she might have felt more comfortable taking disciplinary action which, in turn, might have affected her instructional performance.

If there is a relationship between the evolution of preservice teachers' knowledge about teaching reading and actual practice then certainly it can be assumed that teacher education can make a difference. One of the questions asked of the preservice teachers during the

ordered tree interview concerned what influenced the construction of their trees. All preservice teachers concurred that modeling of reading strategies in the college classroom by the instructor and actual classroom practice helped clarify their declarative knowledge more than any other activity.

Interestingly, not all preservice teachers were able to apply this declarative knowledge equally well in teaching situations. During the reading methods course, all subjects were presented with the same reading strategies which modeled effective instruction but were assigned different grade levels for the field experience portion of the course. Those preservice teachers who taught more effectively tended to pace their lessons well, provided structure for their students, helped set purposes for reading, provided feedback, asked higher-level questions, and generally had a sense of control and confidence. The effective preservice teachers were apparently attending to their students' needs, rather than just teaching content. Conversely, the preservice teachers who were rated as ineffective moved rotely through the reading strategies, failed to respond spontaneously or appropriately to learning breakdowns, did not help students set purposes or tie concepts together, and generally appeared to be more interested in teaching the content rather than teaching the children.

These preliminary findings are interesting and may have implications for teacher education. Keep in mind that this

research is descriptive and exploratory in nature, and, therefore, has limitations as to its generalizability. First, if preservice teachers' knowledge structures about reading evolve and become more coherent over time, and a relationship can be drawn between more coherent knowledge structures and effective reading instruction, then reading methods courses can make a difference. Second, the kinds of instructional practices that are provided in a reading methods course may contribute greatly to how much of a difference. Most reading methods courses model reading strategies in simulated or contrived situations prior to any actual contact with children. The preservice teachers in this study felt modeling was important, but also felt strongly that they have opportunities to apply the reading strategies, not in simulated lessons, but by working with children. Perhaps more opportunities should be provided for preservice teachers to teach. Third, providing effective, although simulated, reading models and encouraging preservice teachers to practice teaching reading strategies with children is evidently not sufficient to produce effective teachers of reading; some preservice teachers were able to teach more effectively than others.

If it is expected that preservice teachers should encourage children to see the connections between what they already know and what they are learning, then perhaps teacher educators need to do similarly. As stated previously, the subjects in this study saw little

relationship between the constructs of the course and actual teaching. It may be worthwhile to help preservice teachers ponder the relationship between how they organize their knowledge and how it affects their approach to instruction. Modeling reading instruction, not in a simulated fashion, but by offering preservice teachers opportunities to observe a teacher or college instructor teaching children to read would involve preservice teachers in an actual instructional event. Follow-up might encourage critical discussion of the reading activity. Was the lesson effective or not effective, and why? Opportunities for the preservice teachers to teach reading lessons to children might be arranged with scheduled feedback or discussion groups. Perhaps peer observation or collaboration would be appropriate. These types of field-based instructional opportunities may help preservice teachers apply their declarative knowledge and may encourage them to see the relationship between the organization of their knowledge and instructional action.

References

Duffy, G. & Roehler, L. (1986). The evolving knowledge structures of five preservice teachers of reading. Unpublished paper, Michigan State University.

Duffy, G. & Roehler, L. (1987). Improving reading instruction through the use of responsive elaboration. The Reading Teacher, 40, 514-521.

Herrmann, B. A. (1987). The relationship between teacher education and prospective teachers' developing knowledge structures for reading and reading instruction. A paper presented at the American Educational Research Association, Washington, D.C.

Naveh-Benjamin, M., McKeatchie, W., Lin, Y. & Tucker, D. (1986). Inferring students' cognitive structures and their development using the "ordered tree technique." Journal of Educational Psychology. 78(2), 130-140.

Paris, S., Lipson, M. & Wixson, K. (1983). Becoming a Strategic Reader. Contemporary Educational Psychology. 8, 663-672.

Roehler, L. (1986). Procedures for scoring the semantic ordered tree. Unpublished paper, Michigan State University.

Roehler, L., Duffy, G., Conley, M., Herrmann, B., Johnson, J. & Michelson, S. (1987). Exploring preservice teachers' knowledge structures. A paper presented at the annual meeting of the American Educational Research Association, Washington, D.C.

Roehler, L., Duffy, G. & Tiezzi, L. (1988). Effective instruction through teacher metacognitive control. A paper presented at the annual conference of the National Reading Conference, St. Petersburg Beach, Florida.

RATING	1	2	3	4	5	6	7	8	9	10	9	8	7	6	5	4	3	2	1
CONCEPTS	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
CHUNKS	3	6	9	12	15	18	21	24	27	30	33	36	39	41	44	47	50	53	56	59	62
AVERAGE CONCEPTS PER CHUNK	4.6	4.4	4.2	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0		
COMBINED DEPTH AND WIDTH	0	2.4	4.8	7.2	9.6	12	14.4	16.8	19.2	21.6	24	26.4	28.8	31.2	33.6	36	38.4	40.8			

FIGURE 1. Rating Scale for Determining Ratings Assigned to Numerical Catagories

concepts = 43
chunks = 16

FIGURE 2. Subject # 5 Arrangement of Terms in Ordered Tree #1

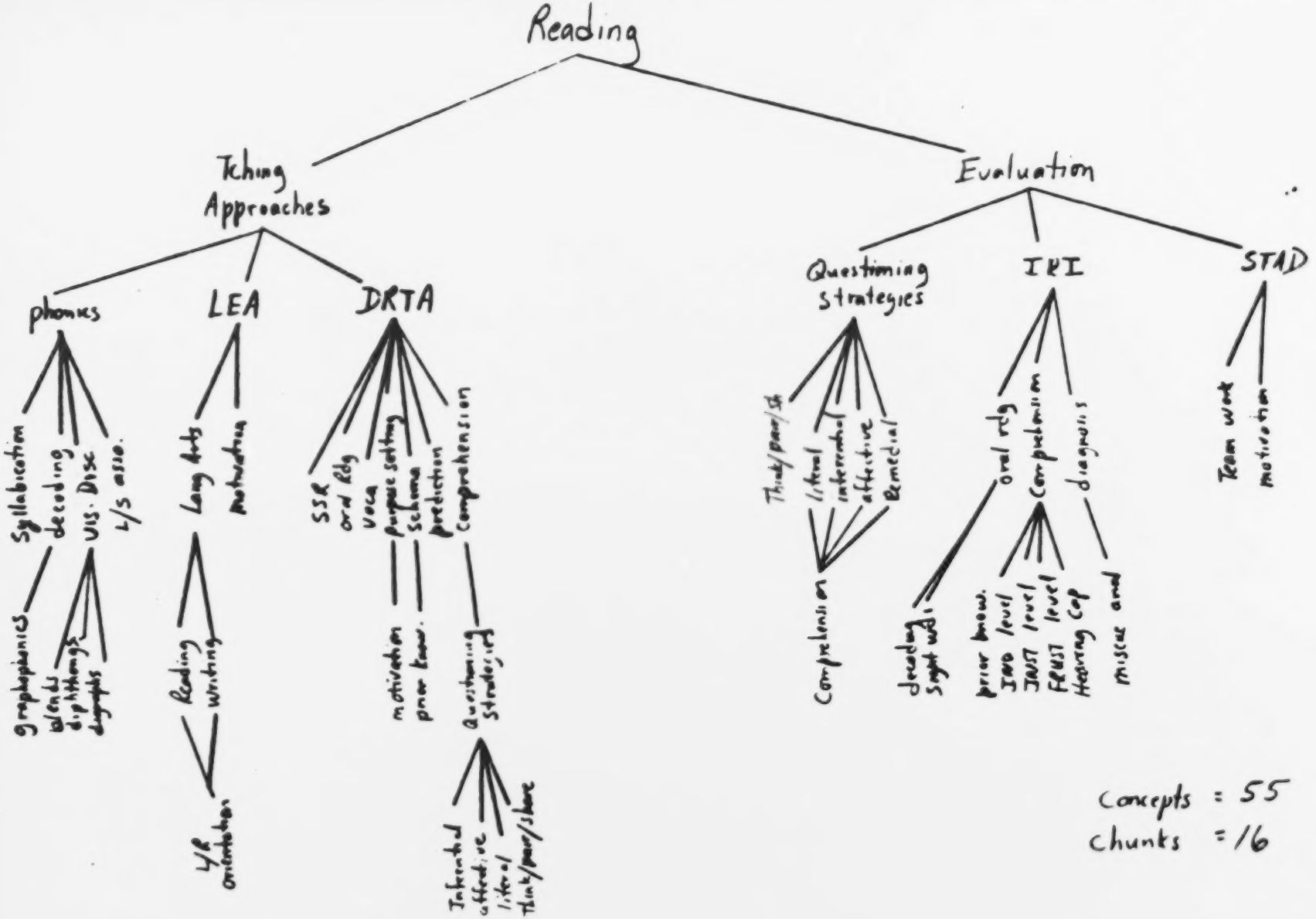
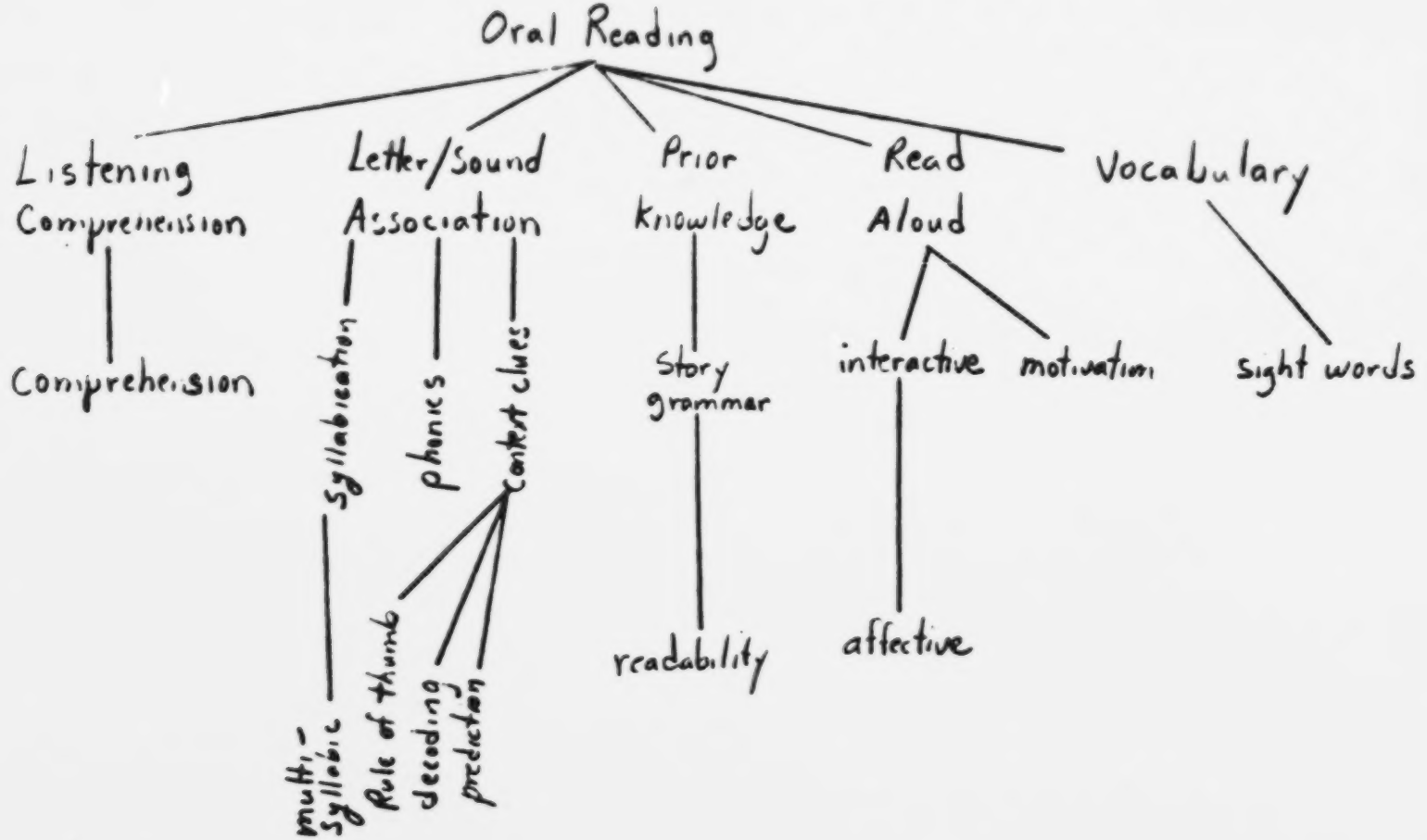
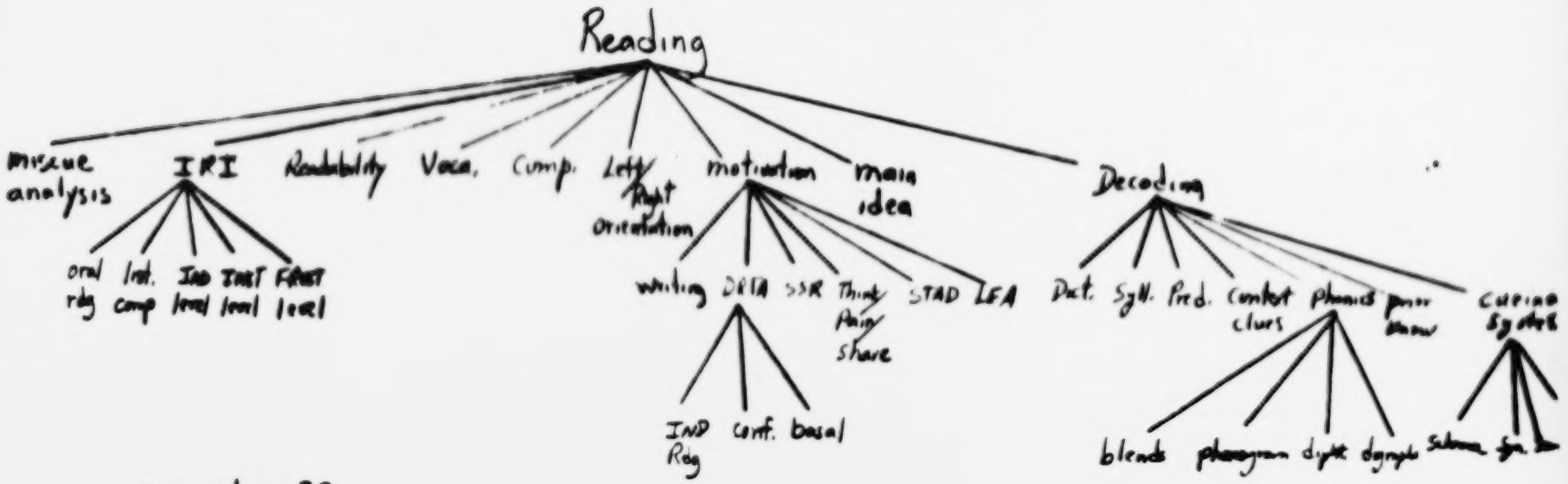


FIGURE 3. Subject 4's Arrangement of Terms in Ordered Tree #3



Concepts = 20
Chunks = 4

FIGURE 4. Subject 6's Arrangement of Terms in Ordered Tree #1



Concepts = 39

Chunks = 7

FIGURE 5. Subject 6's Arrangement of Terms in Ordered Tree #3

Table 1

Overall Ordered Tree Numerical Rating Scores

Subject	OT #1	OT #2	OT #3	Progression of change	
1	2.8	3.1	4.1	↑	↑
2	1.0	3.5	7.5	↑	↑
3	5.9	4.1	6.6	↓	↑
4	5.8	3.3	5.8	↓	↑
5	2.3	5.4	1.8	↑	↓
6	1.9	2.4	1.6	↑	↓
7	2.6	3.2	3.0	↑	↓
8	5.9	5.0	3.9	↓	↓
9	2.5	3.5	3.3	↑	↓
10	5.0	2.5	1.8	↓	↓

Table 2

Overall Ordered Tree Coherence Rating Scores

Subject	OT #1	OT #2	OT #3	Progression of change	
1	1.6	4.5	6.5	↑	↑
2	0	5.6	6.7	↑	↑
3	3.1	5.7	7.7	↑	↑
4	2.6	4.6	8.1	↑	↑
5	1.8	2.3	6.0	↑	↑
6	.2	3.8	5.7	↑	↑
7	2.9	5.3	5.4	↑	↑
8	.4	8.0	6.2	↑	↓
9	4.3	7.4	8.0	↑	↑
10	.5	5.1	5.8	↑	↑

Table 3

Instructional Performance Rating Scores

Subject	Score
1	6
2	10
3	13
4	13
5	5
6	6
7	6
8	7
9	13
10	7